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THE JOURNAL
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NEWLY-DISCOVERED BYZANTINE RECORDS OF COMETS

BY R. F. RODGERS

IN a recent investigation of records of observations of old comets, the writer came across several Byzantine records additional to those already known to astronomers. These references, which may be most conveniently found in the 50-volume Bonn collection *Corpus Scriptorum Historiae Byzantinae*, edited by B. G. Niebuhr, are listed in this paper, together with translations by the author of the descriptions of the comets. References to descriptions of other early comets are given at the end of the article. Dates before Christ are preceded by a minus sign; approximate dates are followed by a colon.

COMET –479:

Joannis Lydi *de Mensibus Speciatim*, Lib. IV, Augustus, Capit. 73, P 118 (Bonn, vol. 27, p. 102, ll. 8–10).

Translation.—Cerastes [was a type of comet], like the crescent moon, which was said to appear when Xerxes invaded Attica.

COMET –348:

Ibid. *Libri de Ostentis Argumenta*, Capit. 10 (Bonn, vol. 27, P 285).

Translation.—Another type of incendiary appears often, such as that seen during the 107th Olympiad [third year], when King Philippus [II], son of Amyntas [II], harassed Greece.

COMET –43:

Ibid. Capit. 10 (Bonn, vol. 27, p. 285).

Translation.—Variegated circles were the fiery names of the type [of comets], one of which appeared when Augustus Caesar enthusiastically entered the city [Roma] in his youth, after the death of his father [Julius Caesar].

COMET 539:

Ibid. Capit. 1 (Bonn, vol. 27, p. 273, l.3 to p. 274, l.7).

Translation.—When observation had shown the truth of these things, and the recent misery of the hairy star [comet], the kind called hippeas, but recently occurred, and because of the irruption of the accursed Persians, who formerly had ventured as far as parts of the Orontes only to retire with all speed, for the star [comet] had foretold victory to the very powerful [Persian] king [Chosroes I Anushirvan]; for these reasons, because of the events themselves, and of their evidence, I was led to recording such matters, on the one hand feeling that this subject would preserve my memory, and on the other that such tasks would not have a lack of disgust and jealousy, if such labor by the ancients in these sciences remained hidden for all time.

COMET 822:

Genesii *Regum Liber II de Michaele Amoriensi*, V 15 C (Bonn, vol. 49, p. 34, l.16 to p. 35, l.1).

Translation.—A comet was seen in the sky as a sort of two moons joined together brightly, and moreover separated by different attachments, in which form it resembled a sort of silhouette of a headless man; this portent foretelling in a certain measure the introduction of the headless dogma of seditious heresy against the [orthodox] Christians; or otherwise, as seems probable, in some way prophesying the folly-bound leadership of that rogue Thomas in the dissension of the repressed foreigners. *Comment.*—This comet must have approached very close to the earth, for its appearance was similar to some telescopic drawings of Comet 1858 Donati.*

COMETS 904, 959:

Leonis Diaconi Caloensis *Historiae*, Lib. I, Capit. 1, P 2 D (Bonn, vol. 33, p. 5, ll. 14–19).

Translation.—Therefore at the time of birth of Emperor Constantinus [VII] Porphyrogenitus, son of Leo [VI Philosophus], for whom a hairy star [comet] was seen at his birth and death, predicting his baptism and departure from life, no proof was required to demonstrate the [comets'] influence, as this was admitted by everyone.

*Guillemin, A., *The World of Comets*, translated into English by J. Glaisher. London, S. Low, Marston, Searle & Rivington, 1877; pp. 253, 338.

COMET 975:

Ibid. Lib. X, Capit. 6, P 104 A (Bonn, vol. 33, p. 168, ll. 10–22).

Translation.—At the same time, in the beginning of August, a hairy star [comet] appeared, a strange and prophetic portent beyond human understanding. We could not recall having seen one so bright, or lasting so many days. Ascending from the place of winter sunrise [south-east] and mounting to a high altitude, erect as a sacred cupressus, and slightly curved, leaning towards the meridian, burning with a great fire and sending forth beams, glittering and bright, it was a sight full of terror and dread to all men. From the beginning of August, I say it was seen for eighty whole days, from when it rose at midnight even until daybreak.

Comment.—This account settles at last the long-standing controversy regarding the identity of this comet with those of 1264 and 1556. If this was an appearance of Comet 1556, then it would have a high northern latitude at the time of observation; the fact that the observed latitude was actually south is proof that this comet was not a reappearance of those of 1264 and 1556.

COMET 1066:

Michaelis Attaliotae *Historia*, f. 185 r. (Bonn, vol. 36, p. 91, l.17 to p. 92, l.2).

Translation.—But in May, Indiction 4, there appeared a comet as bright as the full moon, which set with the sun in the west, and put forth a smoky, cloudy tail; on the following day it began to emit a curly tail, which extended, while the brilliancy of the star [nucleus] decreased; finally, it extended its tail eastward and followed after it, and was visible for forty days.

Comment.—This is an account of one of the most prominent apparitions of Halley's Comet, last seen in its perihelion passage of 1910.

COMET 1078:

Ibid. f. 212 r. (Bonn, vol. 36, p. 211, ll. 8–9).

But some hairy stars [comets] stretched forth in the sky.

The writer would like to thank Mr. C. W. J. Eliot then of the Department of Classics, University College, for making many valuable improvements in the translations.

Philostorgii *Ecclesiasticae Historiae*, comets 389, 400, 418; Socratis Scholastici *Historia Ecclesiastica*, comet 400; Hermiae Sozomeni *Historia Ecclesiastica*, comet 400; Procopii Caesariensis *de Bello Persico*, comet 537 [539], Joannis Malalae *Historia Chronica*, comets 519, 530, 556; Theophylacti Simocattae *Historiarum Genesii*

Regum, comet 595; Anonymi *Antiquitates Constantinopolis*, comet 524; *Chronicon Paschale*, comets 422, 467, 519, 626; Sancti Patris Noster Theophanis Isaacii Isauri *Chronographia*, comets 467, 519, 530, 602, 632, 744, 760, 762, 813; Theophanis Continuati *de Michaele Theophili Filio*, comet 866; Ibid. *de Alexandro Basilii Filio*, comets 904, 912; Ibid. *de Constantino Porphyrogenito Leonis Filio*, comets 904, 959; Symeonis Magistri Metaphrastis ac Logothetae *Annales*, comets 813, 904, 912, 959; Georgii Monachi *de Alexandro Basilii Filio*, comets 904, 912; Leonis Grammatici *Chronographia*, comets 904, 912; Joannis Scylitzae Curopalatae *Excerpta ex Breviario Historico*, comets 1060 [1066], 1071; Georgii Cedreni *Compendium Historiarum*, comets 520 [519], 524, 530, 602, 632, 742, 743, 744, 760, 904, 912, 975, 1029, 1032, 1033, 1034, 1042; Joannis Zonarae *Epitomae Historiarum*, comets 499, 519, 530, 602, 813; Ibid. *Annalium*, comet 1066; Michaelis Glycae *Annalium*, comets 336, 467, 524, 530, 632, 866, 912, 975, 1034, 1041, 1052, 1066; Annae Comnenae *Alexiadis*, comet 1106; Nicetae Choniatae Acominati *Alexius Manuelis Comneni Filius*, comet 1182; Georgii Acropolitae *Annales*, comet 1240; Georgii Pachymeris *de Michaele Palaeologo*, comet 1264 [*not* 1266]; Ibid. *de Andronico Palaeologo*, comet 1301; Nicephori Callisti Xanthopouli *Historiae Ecclesiasticae*, comets 389, 400, 418; Nicephori Gregorae *Historiae Byzantinae*, comets 1266, 1337, 1340, 1345; Ducae Michaelis Nepotis *Historiae Byzantinae*, comets 1402, 1456; Laonici Chalcocondaelae Atheniensis *Historiarum de Rebus Turcicis*, comet 1432; Georgii Phrantzae *Annales*, comet 1454; Georgii Trapezuntii *Claudii Ptolemaei Liber Fructus*, comets 1454, 1456; Georgii Codini *de Originibus Constantinopolitanis*, comet 1106. This list, arranged approximately chronologically according to author, includes only those writers who wrote allegedly original Greek compositions during the time of the Eastern Roman Empire [395-1453 A.D.].

EMISSION LINES IN THE SPECTRA OF LONG-PERIOD VARIABLE STARS*

By Paul W. Merrill
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Long-period variable stars are at the low-temperature end of the trifurcated stellar sequence. Variability cuts across all three branches; it is somehow dependent on low temperature, and not specifically concerned with chemical abundance. That is to say, toward the cool ends of the M, S, and N sequences, the incidence of variability increases, the periods become longer, and there are other correlations, some of which will be mentioned later. Speaking by and large, long-period variable stars are the largest, the coolest, the most tenuous, and possibly the youngest of all stars in the sky. They are probably of population Type I, except for a group of high-velocity variable stars with spectra earlier than M6e and with periods between 150 and 250 days, which are of Type II.

Possibly for the orientation of some who are not spectroscopists, a few general words of description of the Me spectra would be in order. The present discussion will have to do almost altogether with the Me stars. The behaviour of bright lines in the Se stars is similar. The behaviour in the Ne stars is not so very different; although the bright lines are not conspicuous, they probably exist more commonly than we realize. Sanford's work brought this out, and a recent note by Bidelman emphasizes that the kinds of emission that occur in the M stars can occur in the N's, and consequently an explanation has to be such that it will apply to both types. There is no trick by which titanium oxide, for example, will explain the bright lines in variable stars, because in the spectra of some variables the emission lines are present although TiO bands are absent. In the giant M stars, the phenomena of bright lines are well correlated with spectral type. As the spectrum becomes later, and the temperature lower, the form of the light curve and the behaviour of the bright lines undergo change. The period becomes longer, and the bright lines, in general, do exactly the opposite of what common sense might suggest:

*Contributions from the Dominion Astrophysical Observatory, No. 27 (Part 2). This article was prepared from a verbatim record of the lecture given at the symposium on the spectra of emission-line objects at the combined meeting of the American Astronomical Society and the Astronomical Society of the Pacific, in Victoria, B.C., June 1952.

as the temperature becomes lower, the bright lines become stronger. What is the explanation? It must have nothing to do, except indirectly, with the temperature of the photosphere. The phenomena of the bright lines are closely correlated with the phase in the cycle of variability, rather than with the brightness of the star as a whole. The bright hydrogen lines appear *after* the star has passed minimum and is climbing toward maximum. About halfway up the curve the lines increase in intensity, reaching their maximum a little after maximum light. They are followed shortly by the bright lines of metals, especially of iron.

One point should be emphasized. The behaviour of these bright lines is not symmetrical with respect to the light curve. Some elementary text-

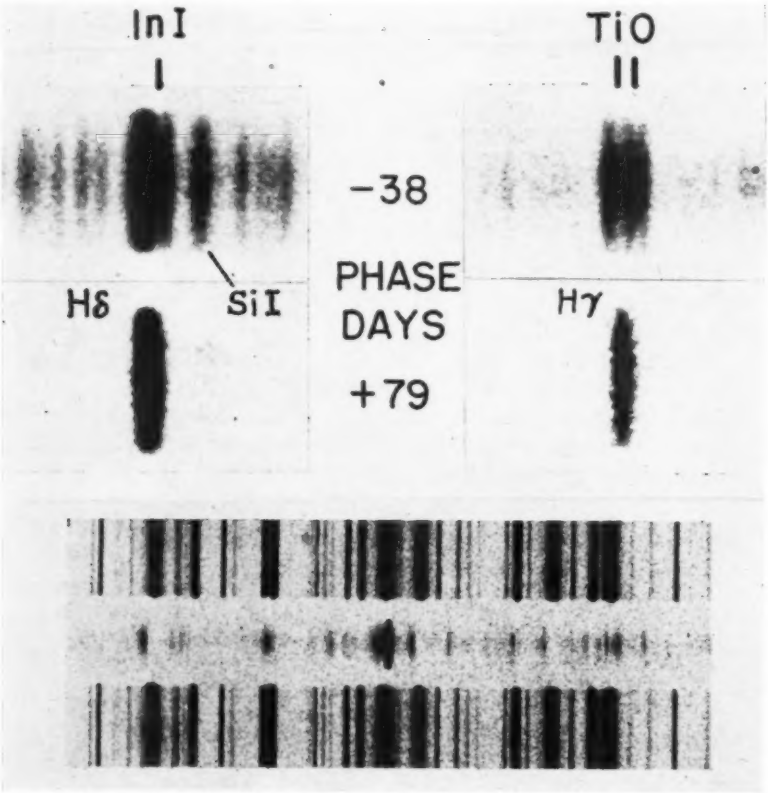


FIG. 1.—*Top*: U Orionis, showing change of emission lines with phase. *Bottom*: χ Cygni, mag. 11.4, 1944 July 10–11, phase + 162 days, showing unidentified line at λ3735.

books have this wrong, and erroneous facts are not likely to yield a correct explanation. The behaviour of the bright lines is in fact not symmetrical about any point of time. The relative intensities of the bright lines and their general behaviour do not depend solely on the magnitude of the star. These remarks about the bright lines do not apply at all to the dark lines. To a first approximation the dark lines do correspond to the magnitude; as the star brightens toward maximum, certain changes take place; as it cools toward minimum, these changes take place in the reverse order. On the other hand the behaviour of the bright lines is to a first approximation a function of elapsed time. The lines run through a sequence, and do not repeat until the next cycle.

The study of the bright lines of long-period variables began in 1885 with the photographic observations of Pickering at Harvard. An interesting sidelight on the psychology of vision arises in the fact that after these bright lines were shown by photography, visual observers saw them; but in the observations of Espin and other early observers there is no record of bright lines before 1885.

The first slit spectrogram of a long-period variable was taken by Wilsing in 1896 at Potsdam. A rapid development followed. Campbell and Wright at the Lick Observatory in 1897-8 studied *o* Ceti with high dispersion. In 1901-2 a second long-period variable star, Cygni, was photographed with moderate dispersion by Eberhart at Potsdam. Then came a very important series of observations of *o* Ceti by Stebbins at the Lick Observatory in 1902. He was the first to show with any definiteness the cyclical behaviour of the bright lines. He did a remarkable piece of work. His observations were so good that part of the probable error in his velocity results came from the errors in the laboratory wave-lengths he had to use. That is not an offhand statement. After the laboratory measures had become more accurate, I took Stebbins' original measures in the stars, and found that his apparent probable errors were reduced. In other words, his measured wave-lengths were more accurate than the laboratory values available at that time; this fact speaks well for pioneer astrophysical technique. Then followed the work of Plaskett, Frost, and Slipher. From 1906 on, observations grew more frequent and more extensive, culminating in 1926 with Joy's investigation of *o* Ceti, by far the finest up to that time. Since that time the effort has been to observe in more detail with higher dispersion many of the features known then and described by Joy.

It is remarkable that bright hydrogen lines should appear in a cool star since they require 13 volts for their production. The reversing layer and the photosphere have nothing like that amount of energy to offer.

Here we come face to face with the mystery: where does the energy to produce the lines come from? The bright lines of neutral metallic atoms that have been identified include those of Mg, Al, Si, Sc, Ca, Mn, Fe, Co, Ni, Ga, Zr, and In. Among the ionized lines are those of Ca, Ti, Mn, Fe, and Sr, and probably the MgII lines near 2800 A. The MgII lines cannot be observed directly because the earth's atmosphere shuts them out, but their presence is inferred by fluorescent effects. Forbidden lines of FeII also are present, but the occurrence of those of other elements is doubtful.

Many irregularities in the Balmer series in emission at first seem mysterious. The apparent absence of the $H\epsilon$ line was early recognized,

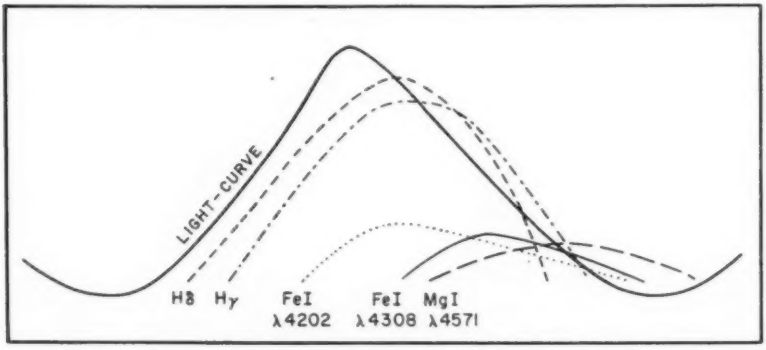


FIG. 2.—Schematic representation of the intensities of emission lines in the spectra of long-period variable stars.

and Miss Agnes Clerke first gave the explanation of its extinction as absorption by the *H*-line of calcium. Other hydrogen lines, however, also show curious discrepancies from their normal laboratory behaviour. The line $H\alpha$ is sometimes not visible at all, although it is normally the strongest line in the series. $H\beta$ also is completely absent from the spectrum at times. It has been shown that these irregularities are closely correlated with the strength of the titanium-oxide bands. This correlation holds in an individual star; and further, the stars with the strongest titanium-oxide bands show the greatest irregularities. Moreover, the hydrogen lines when viewed with high dispersion have considerable structure within them. They *apparently* have *bright* components. The *dark minima*, however, rather than the emission components, are now known to be the significant features. These minima have been the subject of a great deal of work; the latest and best is that by Joy, who made an intensive study of the

minima in the hydrogen emission lines. He confirmed numerous previous identifications, and for the first time identified the markings in the $H\gamma$ line with individual lines in the band spectrum of titanium oxide.

The iron lines also exhibit abnormal intensities. The irregularities of the bright lines, both of hydrogen and of iron, are the greatest when the lines first appear. They become less marked as the phase advances. This fact should guide any general theory of the bright lines. The immediate interpretation is that the source of the bright lines actually rises through the very thick reversing layer.

There is a slight tendency for the velocity curve derived from the dark lines to resemble the light curve, as Joy has brought out. The bright lines are measured shortward with respect to the dark lines. The displacements, therefore, indicate motion outward from the photosphere. The outward velocities of neutral emitting atoms tend to decrease as the cycle proceeds, whereas the velocities of ionized iron atoms and of the hydrogen lines (presumably derived by recombination) tend to increase. These facts may give a hint of electrical or magnetic forces.

I would like to emphasize that the behaviour of the bright lines is a one-way sequence. No configuration is repeated in the same cycle. Think of a street car that starts from the centre of town, changes colour, and grows smaller as it proceeds, finally disappearing at the end of the line, at the edge of town, never to be seen again. Some time before it disappears, another car starts from the centre of town and repeats the same performance. A theory founded on the hypothesis that the street car goes out to the end of the track, turns around and comes back, would not correspond to observation.

The nature of the problem of a long-period variable may be illustrated by a mechanical analogue. Imagine a complicated machine with many moving parts such as gears, cams, belts, and levers. All sorts of miscellaneous things happen: wheels turn at intervals, bells ring, lights of various colours flash on. But the chief occurrence with which all others are in time is the slow rhythmic rise and fall of a vertical rod which extends from the floor above the rest of the apparatus. It is moved by an unseen source of power beneath the floor.

Now hide the whole machine under a flexible blanket, nearly opaque, and you have a mechanical analogue of a long-period variable. The principal thing you can see is a slow rhythmic rise and fall of a hump in the blanket caused by the motion of the top of the rod; and in addition, a few minor motions back and forth in various directions, and an occasional bit of colour dimly seen through the blanket. It would be quite hard to guess exactly what is going on inside. You would realize that some re-

peating mechanism is at work but you could not tell its exact nature nor whether it was mechanical, hydraulic, or electrical.

Distance is the astronomical blanket thrown over a variable star to prevent us from seeing the component parts. It condenses the vast bulk of the star to a mere pin-point of light in which no geometrical detail is visible. But the pin-point has a definite brightness and this corresponds to the height of the top of the blanket. The photosphere corresponds to the floor through which the power comes; it would be opaque even if we got close.

The spectroscope cannot quite remove the blanket but it can tear a few holes through which we get glimpses of what is going on inside. While the piston is rising, a blast of hot hydrogen flashes out; a bit later some incandescent iron appears; as the piston falls a magnesium flare is touched off. What do these fireworks have to do with the rise and fall of

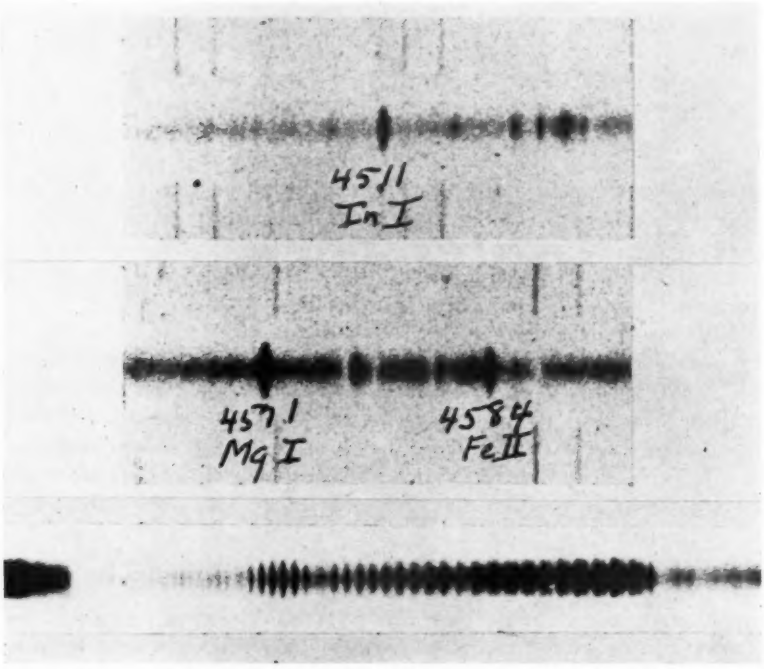


FIG. 3.—*Top* and *Centre*: R Andromedae, mag. 9.7, 1944 November 2, Phase + 103 days. *Bottom*: R Hydrae, mag. 4.7, 1944 February 10, phase—19 days, showing TiO bands near λ4800.

the piston? Nature conducts a wonderful museum but she doesn't hand us any printed cards explaining in words of one syllable the relationships of various happenings. We ourselves have to work out the explanation; and I mean work. Perhaps we need the exercise.

Any successful theory of long-period variables must explain not only the characteristic pattern of spectroscopic behaviour exhibited by numerous objects, it must be sufficiently flexible to account for variations from star to star and from cycle to cycle. The fundamental cause of periodic variation evidently is accompanied by circumstances, possibly relatively minor or fortuitous, which may decidedly modify the observable phenomena. Something similar happens in the earth's atmosphere. Weather cannot be predicted in detail solely on the basis of the diurnal and annual cycles of insolation. One is tempted to carry the analogy further and to suggest that in the Me stars a somewhat variable circulation or turbulence of gases near the surface may cause deviations from a strictly uniform pattern.

The fundamental cause of variability remains obscure, but as far as the phenomena of emission lines are concerned the general hypothesis called for seems rather clearly to be that of the outward propagation of a spherical disturbance originating below the photosphere. This disturbance recurs periodically; it may or may not be connected with a volume pulsation of the whole star; it probably has approximate spherical symmetry. It might possibly come from the centre, like the bubble imagined by Rosseland to explain novae. The reason for Rosseland's suggestions is that pressure and temperature are greatest at the centre and it is here that the limiting physical conditions for some special release of energy would first be reached. The limit, however, must be sharply defined if this is to occur each year for only a month or two. There may, however, be a release of energy nearer the surface. Several investigators have thought of the possibility of the release of energy somehow connected with the dissociation of molecules. Yesterday we heard the interesting idea proposed by McKellar and Odgers that the hydrogen convective zone might give rise to certain spectroscopic effects observed in late-type giant stars. If, as they maintain, this zone is at an appropriate depth, and transports, by means of the ionized hydrogen, the requisite amounts of energy upwards and in a suitably periodic manner, it would appear to have gone far towards filling the requirements. For instance, in their picture the structure in the hydrogen emission lines should be most marked at first appearance, as the observations indicate. On such short notice I cannot fully assess their hypothesis but I see nothing in the overall observational picture to contradict it.

We may return to some speculations of my own on the source and nature of the outbound disturbance. We might think of a shock wave; this would not necessarily greatly disturb the absorbing atmosphere. (Incidentally, a weak shock wave could arise from the disturbance at the top of the convective layer.) Or the disturbance might be in the nature of geysers or prominences passing outward, or of acoustical noise as discussed by Schwarzschild in his paper on the solar corona, or it might be magnetic or electrical. It is probably accompanied by electrical and magnetic effects, whether or not they are fundamental to the phenomena.

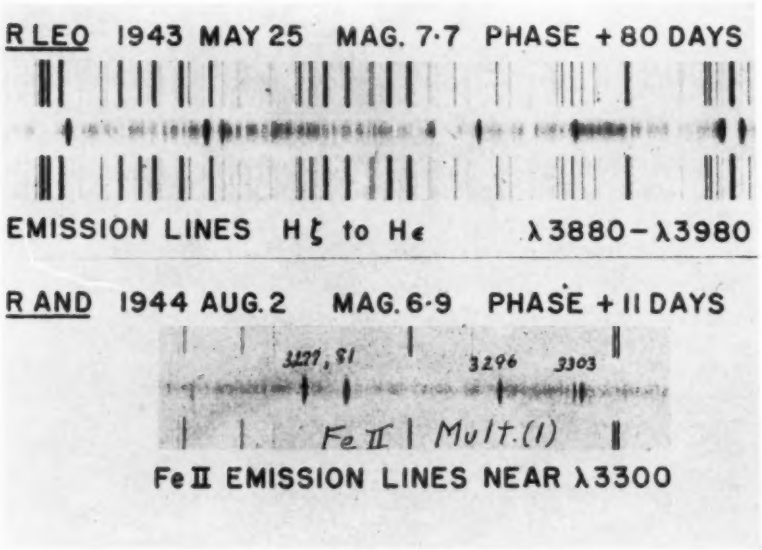

R LEO 1943 MAY 25 MAG. 7·7 PHASE +80 DAYS
EMISSION LINES Hζ to Hε λ3880–λ3980
R AND 1944 AUG. 2 MAG. 6·9 PHASE +11 DAYS
3271, 81
3296
3303
Fe II | Mult. (1)
Fe II EMISSION LINES NEAR λ3300

FIG. 4.—*Top*: R Leonis. *Bottom*: R Andromedae.

Let us assume that beneath the photosphere the disturbance has the general nature of a shock wave advancing outward. The front surface of the wave will be incandescent, and in fact more brilliant than its surroundings because of higher temperature and higher density. Thus by means of light waves it can telegraph ahead, like an atom bomb (but unlike an ordinary supersonic wave in air). It cannot communicate very far ahead, however, because of the high opacity of stellar material below the photosphere. As the shock wave travels outward with a moderate velocity, it will be preceded by a halo of light. The width of the halo will depend upon the opacity of the star and will be greater for longer

wave-lengths. This means that as the shock wave advances, the first thing to strike the photosphere will be the infra-red light. The arrival of this infra-red light at the photosphere is marked by thermal warming and general brightening. The arrival of the ultra-violet light with quanta of higher energy is marked by bizarre spectroscopic effects. The wave proceeds out through the atmosphere with diminishing energy, and a whole series of phenomena follows. This corresponds to the right sequence of happenings, but does not prove the physical interpretation. The outbound disturbance is illustrated schematically in figure 6.

In the outward motion of emitting gases above the photosphere, the acceleration is *inward* for *neutral* atoms such as FeI, SiI, MgI. The corresponding force could be gravity or viscosity. The acceleration is *outward* for *charged* particles such as hydrogen (recombination from H^+),

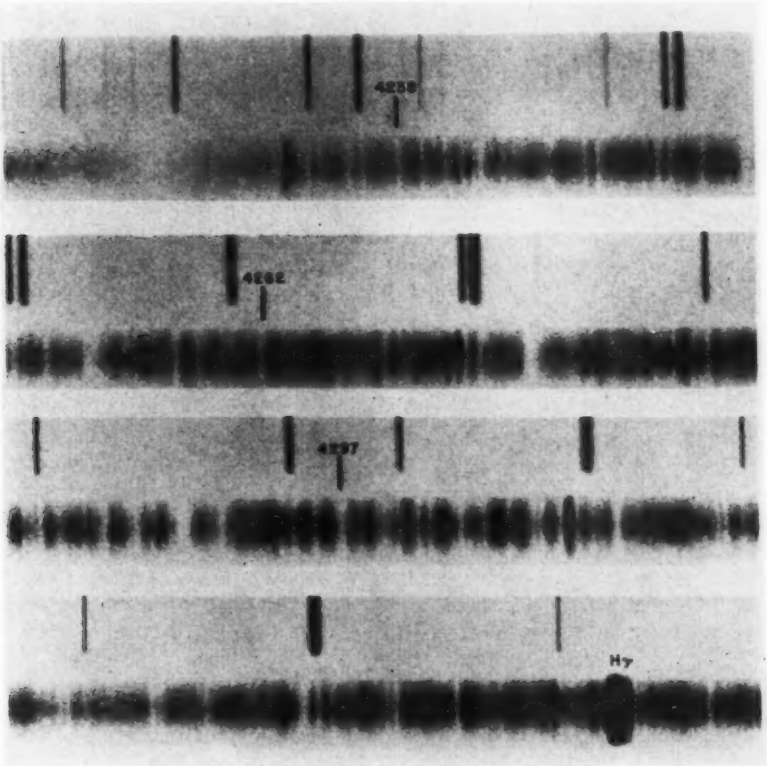


FIG. 5.—R Andromedae, showing technetium lines.

FeII, CaII. (This is what may be expected if the hydrogen convective zone plays the fundamental role, for it is made up of streams of upward-moving hotter ionized material together with corresponding downward streams of cooler neutral material.)

It is a remarkable fact that at no time does the absorption spectrum give evidence of a radical shock. The absorption lines and bands indicate rising temperature during increasing light, falling temperature during declining light. The absence of observable shock may possibly be due to the very great extent of the normal reversing layer. Except for the development of emission on the shortward edges of certain lines, effects other than those of moderate changes of temperature are slight. These facts suggest that the disturbance may proceed in columns (geysers or prominences) that cover only a small fraction of the superficial area of the star. Tremendous changes in apparent photospheric brightness with small changes in the absorption spectrum still afford a certain standing to the veil theory.

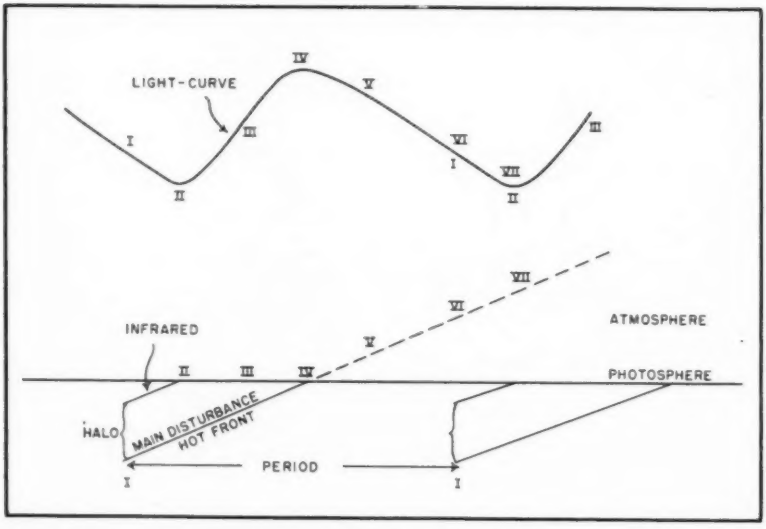


FIG. 6.—Schematic representation of the outward-moving disturbance in long-period variable stars. I—Internal disturbance begins; nothing visible. II—Minimum light: first disturbance (infra-red?) reaches photosphere which begins to brighten. III—Bright hydrogen lines appear: higher quantum energies reach the photosphere. IV—Maximum light: disturbance has now pased through the photosphere which begins to fade. Disturbance in mild form goes on through reversing layer and outer atmosphere. V—Bright hydrogen lines are intense and metallic lines are increasing. VI = I—Hydrogen lines are weaker and metallic lines are stronger. [Fe II] and unidentified lines appear. VII = II—Minimum. Holdover of metallic lines, [Fe II], and unidentified lines. All disappear before III.

WHY DO STARS TWINKLE?*

By M. A. Ellison

'Twinkle, twinkle, little star.
How I wonder what you are?'

Yes, indeed! But the odd thing is that the twinkling has little to do with the nature of stars.

The scientific term for twinkling is *Scintillation*. Scintillation consists of very rapid changes in the apparent brightness of a star—and changes of certain other kinds—colour, position and so on. All these are produced by irregularities in temperature in our own atmosphere, through which the starlight must pass to reach our eyes. But, if we could observe the stars from outside the atmosphere, they would be seen shining with a steady piercing light, and with none of those sparkling flashes of colour that add so much to the beauty and fascination of the night sky.

The astronomer, in the course of his work, takes a much more prosaic view of the matter. For him scintillation is simply a nuisance. When you watch a twinkling star through a telescope, you find that, not only does its light appear to flash up and down, but it changes colour. Worse still, the image is dancing about, up and down and from side to side. Even on nights of the best "seeing", when the telescope is trained on stars high up in the sky, the image is rarely quite still.

I am sure you have noticed this kind of effect, only in a much more exaggerated form. Have you ever looked at some distant object, let us say, over the flames of a bonfire, or across the top of a factory chimney? In either case, the rays of light are bent irregularly by the movement of the hot gases through the line of sight, so that the image is distorted and quivering. Again, on a bright summer's day at the seaside, you may have watched the play of the sunlight, streaming downwards through the water on to the sandy floor of a deep rock pool. You will have noticed how the light is concentrated in an ever-changing pattern of bright streaks and patches—caused by the varying refraction of the little ripples that pass over the surface of the pool.

Well, this is a fairly close analogy to the behaviour of starlight as it shines through the air above our heads. The rays of light must run the gauntlet of countless small ripples of varying density and bending power. These are caused by winds and convection currents located at many different levels; but chiefly, of course, in the denser layers of air within a few miles of ground level.

*Reprinted from *Irish Astronomical Journal*, vol. 2, p. 5, 1952.

Now, this kind of unsteadiness greatly impairs the performance of every telescope. For example, it blurs out the fine details to be seen on the surface of the moon and planets; and it prevents us obtaining sharp images of the stars by photography. Or, again, if we wish to photograph the spectrum of a star, it is essential to concentrate the whole light of the star image on a very fine slit at the entry to the spectroscope. When the image is blurred and dancing about, not much of its light can enter the slit. And so, much longer exposure times are needed to achieve the same result. Astronomers call this bad "seeing".

As we would expect, scintillation becomes less troublesome the greater the height of the observer above sea-level. This is the principal reason why the world's largest telescopes have been erected upon the tops of high mountains, like the 200-inch on Mount Palomar in America. It isn't just to rise above the clouds, as has often been supposed!

The twinkling of the stars has attracted the attention of poets and philosophers throughout the ages, and there have been many strange notions about its cause. The first reference that I have been able to find in scientific literature occurs in Aristotle's book *De Caelo*, written in the fourth century B.C. Now, much of what Aristotle wrote is quite unacceptable to modern science. But there is one passage of great interest in his book about the heavens, where he asks the question: "Why do the stars twinkle?", and then sets out to answer it. He remarks, quite correctly, as I'm sure many of you have noticed for yourselves, that it's the *fixed* stars which twinkle, while the wandering stars—or planets—do not.

Nowadays, *we* believe that when we look at a star, the rays of light that fall on our eyes have been travelling for many years across the intervening space. When a part of that light is concentrated by the lens of the eye on the retina, a visual image is created by the brain. But some Greek philosophers held the contrary view. *They* had the notion that, in the act of vision, the eye sent out a kind of invisible tentacle, which grasped hold of the object, so to speak, and then transmitted back to the brain a message of what it had found at the other end. Aristotle made use of this idea to explain both the twinkling of the stars and the comparatively steady light of the planets. He said (I give you the translation): "The planets are near us, so that the visual ray (that is, the tentacle) reaches them in its full vigour, but when it comes to the stars (which are much farther off) it is quivering because of the distance and its excessive extension".

These and other wrong ideas were current right down through the middle ages. In the 16th century the famous astronomers, Giordano Bruno and the great Tycho, held that scintillation was caused by the rapid rotation of the stars on their axes—in much the same way as a diamond flashes when it is rotated in a beam of light—presenting in turn different

facets to the eye of the beholder. The planets didn't rotate, or so they believed (this was before the invention of the telescope), and so they didn't scintillate! Kepler and Galileo considered that the stars must be subject to "paroxysms", or, as we should say, that they were variable stars. Many stars, indeed, *are* variable, but their light fluctuations are measured in hours, or days, rather than in fractions of a second.

It was in the 17th century that Huygens, Hooke and Newton, profiting by the newer theories of optics, arrived at the modern standpoint; namely, that scintillation arises from irregular refractions of the rays of light as they traverse our own atmosphere.

We are still very far from a complete understanding of the facts of twinkling and of their interpretation. For example, what causes the scintillation colours visible in a bright star like Sirius at low altitude? This star can be seen any evening just now. You can try this simple experiment for yourself. Focus a pair of field glasses on Sirius. Then rapidly vibrate one end of the instrument with your hand, so that the star image is drawn out into a circle or oval. The effect is one of extreme beauty; the curved line of light is divided up into a splendid array of sparkling colours. One part is red, another green, another violet, and some are of mixed shades. It is evident from this experiment that at any instant only a part of the light of the star reaches our eyes; at one moment, the blue end of the spectrum is destroyed and the star looks reddish; at the next, the red light is removed and the star looks blue-green, and so on. To the Greeks Sirius was The Hot Scorching One, but to the more keenly observant Arabs it was Barakesch– the star of a thousand colours. What a vivid and appropriate description!

The fundamental difficulty in the scientific study of scintillation has been this: both the eye and the photographic plate (until now the chief weapons of the astronomer) were quite unsuited to appreciate or to record light flashes occurring at a rate of about 100 times a second. In the past two years my colleague, Mr. Harry Seddon and I, working at the Royal Observatory, Edinburgh, have developed a piece of electronic equipment that does not suffer from these limitations. Indeed, our apparatus will give an exact record of the intensity variations in a source of light that is flashing up and down as fast as 10,000 times a second.

Let me tell you briefly how this equipment works. We use a 36-inch telescope. At the principal focus of this telescope the light from a star is concentrated on the sensitive surface of a photo-electric cell. A photocell looks rather like a wireless valve: it converts the feeble light energy of the star into an electric current. A special arrangement built into the cell then magnifies that current a million times. So, instead of measuring the brightness of the star directly, we measure the electric current which the star-

light causes to flow. If the starlight fluctuates, so does the current in exact proportion.

Our next step is to produce a visible record of this minute current: its strength is still only a few millionths of an ampère and it is fluctuating perhaps 100 times a second. We feed it into an amplifier, not unlike a wireless set, which magnifies it a further 1000 times. Finally, the electricity is applied to a cathode ray tube, like those in a television set, and we get, not a picture, but a spot of light, which dances up and down in harmony with the light flashes of the star. But how do we get permanent records of this dancing? Well, we focus a cine-camera on the screen, and while the spot of light dances vertically the film runs through at high speed horizontally. When the film has been developed we have a faithful record of the scintillations of the star, drawn out on such a large scale that one foot of film represents about one second of time.

Once we have this record, we can sit down and study the scintillations at our leisure, and compare them for different altitudes and for different weather conditions.

Many new facts have come out of these experiments. We have found, for instance, that while the planets with large discs, like Jupiter and Saturn, don't normally scintillate, the smaller planets and satellites twinkle precisely like the stars. We have also been able to measure the average size of the atmospheric irregularities causing scintillation (about 3 inches) and their average height (about 8000 feet).

Quite recently the radio astronomers have become interested in scintillation. As you may know, they have been receiving radio waves at metre wave-lengths from many parts of the sky. These waves pass in freely through the atmosphere and are concentrated to a focus by means of large parabolic aerials which have come to be known as radio-telescopes. But when a star has been located in a radio-telescope we don't usually find any *visible* star in that direction. And so, for the time being, the sources of the waves have been christened "radio stars".

Now the radio astronomers at the Universities of Manchester and Cambridge have made the discovery that the radio stars also twinkle; notwithstanding the fact that the radio waves are ten million times longer than the waves of light. They believe that radio twinkling occurs when the incoming waves are traversing the ionosphere at a height of about 200 miles—what we now call the Appleton layer.

'Twinkle, twinkle, little star . . .'

Yes, it isn't only in the nursery that it is a matter for wonder!

Royal Observatory,
Edinburgh, 9.

OUT OF OLD BOOKS

By Helen Sawyer Hogg

The Introduction of the Copernican System to England

III. Thomas Digges and *A Perfit Description of the Caelestiall Orbes.*

Pupil and close associate of John Dee, Thomas Digges made a lasting contribution to English astronomy, though the period during which he did most of his work was only a decade. His most famous publication, however, one on the Copernican system, was printed in at least seven editions, from 1576 down to 1605, thereby exerting a great influence on English thought during the last quarter of the sixteenth century. A full description of the work of Thomas Digges is given by Francis R. Johnson in his volume, *Astronomical Thought in Renaissance England*, from which we quote by kind permission of The Johns Hopkins Press.

Thomas Digges was born about 1546, the son of the famous mathematician Leonard Digges, who died when Thomas was thirteen. After his father's death Thomas became closely associated with John Dee, whom he calls his "second parent" in mathematics and astronomy, stating that Dee had "sown many seeds of those most sweet sciences" in his mind during "his most tender years" and had "nurtured and increased others which previously had been sown in a most loving and faithful manner by his father."

By 1573, when Digges was only twenty-seven, he ranked with Dee as one of the two leading mathematicians and astronomers in England. In February of that year he published his book on the new star of 1572, the *Alae seu Scalae Mathematicae*. Next to Tycho's this book contains the best published observations of this famous star. Tycho himself thought so highly of Digges' observations that in his *Progymnasmata*, which was a summary of all the treatises written on this star, he devoted over thirty pages to Digges' work, about twice as many as any other single work received. Johnson thinks that the instrument Digges used was the famous ten-foot cross staff designed by Chancellor and Dee, and mentioned in our article on the latter. Dee's own work on this star was published a little later.

Tycho, Dee and Digges all eagerly made measures of the new star in an attempt to determine its shift in parallax, and thereby prove the Copernican theory of the revolution of the earth. It is one of the ironies

of early science that they selected a star of the highest possible absolute magnitude, a supernova, hence the one kind of star visible to the ends of the universe, and therefore on an average having the smallest parallactic shift of any! Even with our modern instruments we could not measure a direct trigonometric parallax for this star.

Camden, in his annals of the reign of Elizabeth, says (Johnson, p. 156):

> I know not whether it be worth the labour to mention that which all historians of our time have recorded, to wit, that in the month of November, a new star, or if you will, a phenomenon was seen in the constellation of Cassiopeia, which (as I my self observed) in brightness excelled Jupiter in the Perigee or nearest point of the excentric and epicycle: and in the same place it continued full sixteen months, being carried about with the daily motion of the heaven.
>
> Thomas Digges, and John Dee, Gentlemen, and Mathematicians amongst us, have learnedly proved by paralactic doctrine, that it was in the celestial, not in the elementary region: and they were of opinion that it vanished little by little in ascending. Certainly after the eighth month all men perceived it to grow less and less.

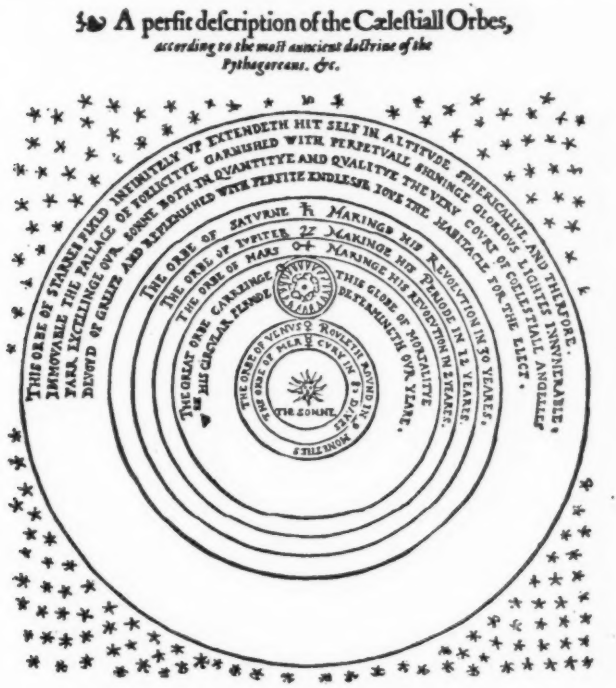
The importance of this new star in scientific thought can hardly be over-estimated. Once its lack of parallax was established, it had to be admitted that the star was farther away than the moon. This automatically meant a rejection of the iron-clad Aristotelian idea that there could be no change in the fixed realm of the stars.

The *Alae* consists of new trigonometric theorems for determining parallax, Digges' observations of the new star, and a discussion of the value of the observational approach in science as opposed to a theoretical one. Digges states (as translated by Johnson, page 159):

> I have perceived that the Ancients progressed in reverse order from Theories, which were clearly false, to seek after true Parallaxes and distances, when they ought rather to have proceeded in inverse order, and from Parallaxes, which have been observed and are known, they ought to have examined Theories. By this method it would not be at all difficult, if this remarkable Phenomenon should persist for a long time, to discern by exact judgment whether the Earth lies quiet and immovable in the center of the World, and whether that huge mass of moving and fixed Orbs rotates in a circle by a most rapid course in the space of 24 hours, or rather, that that immense sphere of fixed stars remains truly fixed and that apparent motion occurs only from the circular rotation of the Earth with reference to the celestial Poles themselves. . . .
>
> Therefore, I have thought not only that a treatment of this subject is necessary, but also that Mathematics has rules for measuring the location, distance and magnitude of this stupendous star, and for manifesting the wonderful work of God to the whole race of mortals (who strive to understand something Celestial and lie not wholly buried in the earth); also for examining Theories and establishing the true System of the Universe, as well as for measuring most accurately the Parallaxes of Celestial Phenomena.

This book made Thomas Digges one of the leaders of scientific thought in England, but it was written in Latin and understood by scholars only.

In 1576 a new edition of the famous work by Leonard Digges, *Prognostication euerlasting*, was being prepared and Thomas seized the opportunity to add a supplement to his father's work. This supplement gave an English translation of the principal sections of Book I of Copernicus' *De revolutionibus*, and a diagram of the heliocentric system which we reproduce here. It is entitled "A Perfit Description of the Caelestiall Orbes


A perfit deſcription of the Cæleſtiall Orbes,
according to the moſt auncient doctrine of the Pythagoreans. &c.
THIS ORBE OF STARRES FIXED INFINITELY VP EXTENDETH HIT SELF IN ALTITVDE SPHERICALLYE AND THEREFORE IMMOVABLE THE PALLACE OF FELICITYE GARNISHED WITH PERPETVALL SHININGE GLORIOVS LIGHTES INNVMERABLE FARR EXCELLINGE OVR SONNE BOTH IN QVANTITYE AND QVALITYE THE VERY COVRT OF CAELESTIALL ANGELLES DEVOYD OF GRIEFE AND REPLENISHED WITH PERFITE ENDLESSE IOYE THE HABITACLE FOR THE ELECT.
THE ORBE OF SATVRNE ♄ MAKINGE HIS REVOLVTION IN 30 YEARES.
THE ORBE OF IVPITER ♃ MAKINGE HIS REVOLVTION IN 12 YEARES.
THE ORBE OF MARS ♂ MAKINGE HIS REVOLVTION IN 2 YEARES.
THE ORBE OF VENVS ♀ ROVLETH ROVND IN 9 MONETHS.
THE ORBE OF MERCVRIE ☿ CVRSETH IN 3 MONETHS.
THE GREAT ORBE GARNISHED WITH STARRES.
THE CIRCVLAR ELEMENT.
THE GLOBE OF MOONE ☽ DESCRIBETH OVR YEARE.
THE SONNE.

according to the most aunciente doctrine of the Pythagoreans, latelye reuiued by Copernicus and by Geometricall Demonstrations approued."

The translation of Copernicus' work is an excellent one, done phrase by phrase in the Elizabethan style rather than word by word, and various interpretations by Digges are worked into it. The most noteworthy addition is Digges' conception that the stars are at varying distances from us, not fixed to one finite outer wall. Johnson says that Digges "was the first modern astronomer of note to portray an infinite, heliocentric universe, with the stars scattered at varying distances throughout infinite space."

Digges' diagram of the universe, first printed in 1576 and then in all later editions of the *Prognostication*, was the same as the diagram in *De revolutionibus* for the planetary system, but instead of representing a sphere for the stars, it scattered them around at varying distances to the edge, and inserted the legend:

> This orbe of starres fixed infinitely vp extendeth hit self in altitude spherically, and therfore immouable; the pallace of foelicitye garnished with perpetuall shininge glorious lightes innumerable, farr excellinge our sonne both in quantitye and qualitye . . .

Into the fabric of the translation of Copernicus, Digges wove the following paragraph of his own, appraising the position of the earth, "this litle darcke starre", in the vast universe (Johnson, page 165):

> Heerein can wee neuer sufficiently admire thys wonderfull & incomprehensible huge frame of goddes woorke proponed to our senses, seinge fyrst thys baull of y^e^ earth wherein we moue, to the common sorte seemeth greate, and yet in respecte of the Moones Orbe is very small, but compared with *Orbis magnus* wherein it is caried, it scarcely retayneth any sensible proportion, so merueilously is that Orbe of Annuall motion greater than this litle darcke starre wherein we liue. But that *Orbus magnus* beinge as is before declared but as a poynct in respect of the immesity of that immoueable heauen, we may easily consider what litle portion of gods frame, our Elementare corruptible worlde is, but neuer sufficiently be able to admire the immensity of the Rest. Especially of that fixed Orbe garnished with lightes innumerable and reaching vp in *Sphaericall altitude* without ende. Of whiche lightes Celestiall it is to bee thoughte that we onely behoulde sutch as are in the inferioure partes of the same Orbe, and as they are hygher, so seeme they of lesse and lesser quantity, euen tyll our sighte beinge not able farder to reache or conceyue, the greatest part rest by reason of their wonderfull distance inuisible vnto vs. And this may wel be thought of vs to be the gloriouse court of y^e^ great god, whose vnsercheable worcks inuisible we may partly by these his visible coiecture, to whose infinit power and maiesty such an infinit place surmountinge all other both in quantity and quality only is conueniente. But because the world hath so longe a tyme bin carryed with an opinion of the earths stabilitye, as the contrary cannot but be nowe very imperswasible, I haue thought good out of *Copernicus* also to geue a taste of the reasons philosophicall alledged for the earthes stabilitye, and their solutions, that sutch as are not able with *Geometricall* eyes to beehoulde the secrete perfection of *Copernicus Theoricke*, maye yet by these familiar, naturall reasons be induced to serche farther, and not rashly to condempne for phantasticall, so auncient doctrine reuiued, and by *Copernicus* so demonstratiuely approued.

Among the more important ideas in other published works of Digges are those on "perspective glasses". These remarks show Digges' familiarity with the essential optics of a telescope. Almost certainly Digges had something resembling a telescope. In 1571 in his *Pantometria*, a book setting forth geometrical methods in surveying, Digges wrote, at the end of Chapter 21 of the first book (Johnson, page 175):

Thus much I thought good to open concerning the effects of a plaine Glasse, very pleasant to practise, yea most exactly seruing for the description of a plaine champion countrey. But marueilous are the conclusions that may be performed by glasses concaue and conuex of Circulare and parabolicall formes, vsing for multiplication of beames sometime the aide of Glasses transparent, which by fraction should vnite or dissipate the images or figures presented by the reflection of other. By these kinde of Glasses or rather frames of them, placed in due Angles, yee may not onely set out the proportion of an whole region, yea represent before your eye the liuely image of euery Towne, Village, &c. and that in as little or great space or place as ye will prescribe, but also augment and dilate any parcell thereof, so that whereas at the first apparance an whole Towne shall present it selfe so small and compact together that yee shall not discerne anye difference of streates, yee may by application of Glasses in due proportion cause any peculiare house, or roume thereof dilate and shew it selfe in as ample forme as the whole towne first appeared, so that ye shall discerne any trifle, or reade any letter lying there open, especially if the sunne beames may come vnto it, as plainely as if you were corporally present, although it be distante from you as farre as eye can discrie: But of these conclusions I minde not here more to intreate, hauing at large in a volume by it selfe opened the miraculous effects of perspective glasses.

Unfortunately there is no known copy of the volume on perspective glasses mentioned in this paragraph. The above quotation, however, should show beyond doubt that the telescope was not the invention of one person, as for example the most commonly cited Jan Lippershey, but was the product of the accumulated ideas of a number of people. And in placing credit for the invention of the telescope, far too little acknowledgement is given to the English group of scientists who worked before 1600. Digges must have had a fairly strong lens or mirror if he was able to read letters lying on tables in his neighbours' houses!

The existence and power of Digges' lenses and mirrors are corroborated in a treatise by William Bourne. This treatise was written about 1580, at the request of Lord Burghley, and discusses the manufacture and properties of convex and concave mirrors, and convex lenses. We read that in those days too the expense of instruments was a hindrance to their development (Johnson, page 177):

For that the habillity of my purse ys not able for to reache, or beare the charges, for to seeke thorowly what may bee done with these two sortes of Glasses, that ys to say, the hollowe or concave glasse: and allso that glasse, that ys grounde and polysshed rounde, and thickest on the myddle, and thynnest towardes the sydes or edges, Therefore I can say the lesse vnto the matter. For that there ys dyvers in this Lande, that can say and dothe know muche more, in thes causes, then I: and specially Mr. Dee, and allso Mr. Thomas Digges, for that by theyre Learninge, they have reade and seene many moo auctors in those causes: And allso, theyre ability ys suche, that they may the better mayntayne the charges: And also they have more leysure and better tyme to practyze those matters, which ys not possible for mee, for to knowe in a nombre of causes, that thinge that they doo knowe. But notwithstanding upon

the smalle proofe and experyence those that bee but vnto small purpose, of the skylles and knowlledge of these causes, yet I am assured that the glasse that ys grounde, beynge of very cleare stuffe, and of a good largenes, and placed so, that the beame dothe come thorowe, and so reseaved into a very large concave lookinge glasse, That yt will shew the thinge of a marvellous largeness, in a manner vncredable to bee beleeved of the common people. Wherefore yt ys to bee supposed, and allso, I am of that opinyon, that havinge dyvers, and sondry sortes of these concave lookinge glasses, made of a great largeness, That suche the beame, or forme and facyon of any thinge beeynge of greate distance, from the place, and so reseaved fyrste into one glasse: and so the beame reseaved into another of these concave glasses: and so reseaved from one glasse into another, beeynge so placed at suche a distance, that every glasse dothe make his largest beame. And so yt is possible, that yt may bee helpped and furdered the one glasse with the other, as the concave lookinge glasse with the other grounde and polysshed glasse. That yt ys lykely yt ys true to see a smalle thinge, of very greate distance. For that the one glasse dothe rayse and enlarge, the beame of the other so wonderfully. So that those things that Mr. Thomas Digges hathe written that his father hathe done, may bee accomplisshed very well, withowte any dowbte of the matter: But that the greatest impediment ys, that yow can not beholde, and see, but the smaller quantitye at a tyme.

Is it possible, that Digges, with such perspective glasses in his hands, and with his keen love and understanding of astronomy, never turned the glasses toward the heavens? There are no extant references which state that he did, but two things suggest that he might have done this. One is his steadfast clinging to the Copernican theory in spite of the disappointing failure to measure a parallax for the new star of 1572. Was it because his crude lenses or mirrors had shown him the depth of stars in the Milky Way that Digges was such a stalwart supporter of Copernicus? Was it observations of fainter stars that caused him to scatter the stars at varying distances?

A second suggestion that possibly Digges had looked at the heavens with perspective glasses comes from a list he printed of "Bookes Begon by the Author, heerafter to be published", in 1579, among which was

Commentaries vpon the *Reuolutions* of *Copernicus*, by euidente Demonstrations grounded vpon late *Obseruations*, to ratifye and confirme hys *Theorikes* and *Hypothesis*, wherein also Demonstratiuelie shall be discussed, whether it bee possible vpon the vulgare *Thesis* of the Earthes *Stabilitie*, to delyuer any true *Theorike* voyde of such irregular Motions, and other absurdities, as repugne the whole *Principles* of *Philosophie* naturall, and apparant groundes of common *Reason*.

The reference to "late observations" is both intriguing and important. What these observations were remains unknown. There is however still hope that more references to them may be found. According to Johnson there are numerous letters written by Digges, now in the Public Record Office, the British Museum, and elsewhere, which, if thoroughly studied may yield a clue. It appears obvious that the English astronomers of this

period get too little credit for their work because they did not get into print as much knowledge as they possessed.

After 1580 Digges had little opportunity to pursue his scientific investigations before his death in 1595. As so often happens in later years, his various talents made him much in demand for other things, such as the supervision of military fortifications. Furthermore, in 1583 Dee's establishment at Mortlake was sacked by a mob, which destroyed the instruments and laboratories. There were other English scientists, however, who were carrying on experiments with lenses and mirrors, in particular Thomas Harriot, of whose accomplishments we shall write in a later JOURNAL.

VARIABLE STAR NOTES

American Association of Variable Star Observers

By MARGARET W. MAYALL, *Recorder*

THE 1952 Spring Meeting of the A.A.V.S.O. was held at Clarkson College of Technology on May 23 and 24. Professor Francis H. Reynolds and his helpers made it one of the finest meetings on record. About thirty members and guests from Canada and the United States made their way to the little New York State town of Potsdam.

The programme was started off Friday evening with a very instructive talk by Professor Frank Record, on the applications to astronomy of the new sciences of radar and electronics. Ten more papers were presented by the members on Saturday: The New Observatory at Colgate University, by Harold H. Lane; Some Remarks about Aurorae, S. L. Boothroyd; Remarks on the Coming Sun-spot Minimum, W. Gleissberg (read by Neal Heines); On Observing Sun-spots, Walter L. Moore (read by Prof. Reynolds); Variable Stars in Globular Clusters, Mrs. Helen S. Hogg; Using Becvar Atlas Charts in Observing Variable Stars, Clinton B. Ford; The Canadian Super Schmidt, Peter M. Millman; Remarks on Some Variables, Mrs. Margaret W. Mayall; Statistical Methodology in Relation to the Granulation Project, James C. Bartlett, Jr. (read by Peter Millman); Model of Eclipsing Variables, J. J. Ruiz. Abstracts of these papers are being printed by the A.A.V.S.O. and distributed to members. Anyone else who wishes a copy may have one by writing to the A.A.V.S.O. Headquarters, at Harvard College Observatory, Cambridge 38, Massachusetts.

The Flare Star, 013418 UV Ceti. The following note on the observation of a flare of UV Ceti was translated from the German by Dr. Joseph Ashbrook. The note was printed originally in *Nachrichtenblatt der Astronomischen Zentralstelle*, 5. Jahrgang Nr. 10, 1951 Nov. 24.

"On 1951 October 12 a sudden flare of the red dwarf UV Ceti was observed. Observation of the field was interrupted for not over a minute; the next glance into the eyepiece showed the star markedly brighter and noticeably increasing. Maximum occurred one-half minute later at 23^h17^m U.T. at least two magnitudes brighter than normal, from a subsequent comparison with BD $-18°275$ ($9^m.1$). A conspicuous red colour was not observed. At once the brightness declined, and at 23^h21^m U.T. the star was again normal, $0^m.1$ fainter than Luyten's comparison star c. The rapidity of the phenomenon shown by this visual observation shows that it will be necessary, though difficult, to take precautions against haste and preconception when observing stars of this type. H. v. Socher, Vienna, 1951 October 16."

AE Aquarii Month. July 1952 was designated AE Aquarii Month by the A.A.V.S.O., in the hope that enough observations could be collected from all around the world to make a detailed study of the rapid variations known to occur. Mr. F. Lenouvel, of the Observatoire de Haute Provence, France, observed the star with a photoelectric photometer attached to the 120-centimetre telescope, on five consecutive nights, and obtained 14 metres of tracings. He caught many explosions, with rapid changes showing up on his tracings within periods of 10 to 15 minutes. Mr. Lenouvel will measure his tracings and publish a full report as soon as possible.

Gunnar Darsenius in Sweden and Per Darnell in Denmark simultaneously observed a maximum on J.D. 2434219.4. George Isaak in Australia observed a maximum on 4225.2, and Curtis Anderson in Milwaukee observed one on 4225.8. Several other maxima were observed by two or more members. One on 4211.7 was observed by Reynolds, Ford, Ashbrook, Fernald, and Rosebrugh. Observations of other maxima have been received from Galbraith, Lacchini, Charles, and LeVaux. At the time of writing this note (the middle of August), we have received observations of 14 maxima during the month of July, and there are many observers not yet heard from.

Eta Carinae. The famous variable star and former nova in the heart of the Carina nebula has been showing increased activity in the last few months. Our South African member, Arthur Morrisby, of the Cape Observatory, writes that a friend of his, Mr. Archer, has found it varying rapidly and irregularly between the 5th and 8th magnitudes.

Annual Fall Meeting. The 41st Annual Meeting of the A.A.V.S.O. will be held at the Harvard Observatory, Cambridge, Mass., on October 17 and 18, 1952.

P.E.P. Observations. Many variable stars have ranges too small for visual observations. The photoelectric photometer (P.E.P.) is the ideal instrument for measuring these stars, but unfortunately there are not enough of them in use to take care of all the problems. The A.A.V.S.O. is fortunate in having for one of its members Mr. John J. Ruiz, of Dannemora, New York, who has a love of gadgets and experience in electronics. Mr. Ruiz has submitted the following paper, which tells of his work on the star 12 Lacertae (DD Lac), a short-period variable of the Beta Canis Majoris type, which has three overlapping periods, and a variation in magnitude from about 5.0 to 5.1. (See also the story by Mr. Ruiz, "The Gremlins and My Photometer," *Sky and Telescope*, p. 43, Dec. 1951.)

LIGHT CURVES OF 12 LACERTAE

By John J. Ruiz

These ten light curves (see figure) of 12 Lacertae (223749, DD Lac) were taken during the summer and fall of 1951, using a 1P21 photo-multiplier tube without any filters. We may assume that these curves correspond to the maximum response of this tube, i.e. in the 4200A. region. The comparison star was 10 Lacertae.

Three types of amplifiers were used, a Kron type,[1] a Bridge type similar to the RCA-WV-84A micro-ammeter and the third, having a single electrometer tube by Baum.[2] All observations taken with the last two were corrected for non-linearity.

The short vertical lines near the observed maxima represent the time of the computed maxima from the formula:

$$\text{Max.} = \text{J.D. } 2421439.776 + 0.1930802E,$$

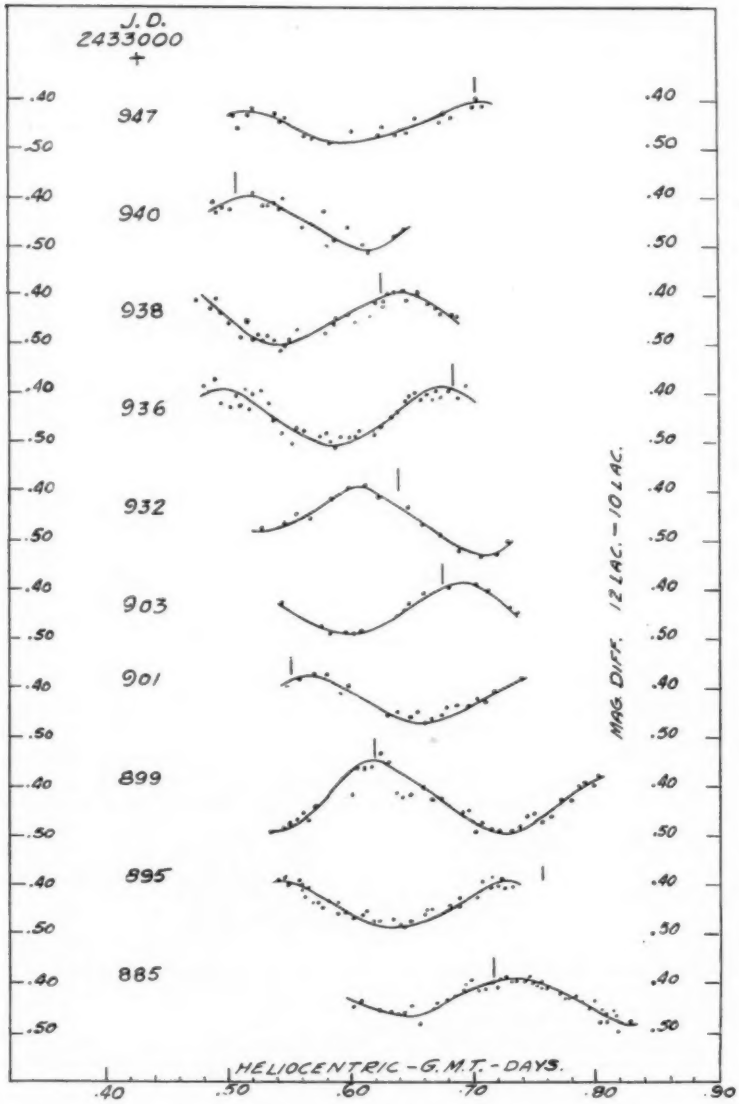
established by Fath in 1947.[3]

Deviations of the observed maxima from the computed, range from −0.035d to +0.018d, the average being +.004d. Fath found deviations ranging from −0.040d to +0.036d, average ± 0.014d.

The amplitudes range from 0.053 mag. to 0.143 mag. The number of observations was not sufficient to catch the star at its lowest and maximum amplitudes. Fath found amplitudes ranging from 0.022 to 0.189 mag.

The period based on a lapse of only 274 cycles comes out 0.19308d the last two figures being uncertain.

The correction for differential atmospheric extinction in the case of these two stars which are close together and were observed near the zenith, is very small and hardly



Observations of 12 Lacertae.

warranted by the accuracy of the present observations, which are greatly affected by lack of atmospheric constancy of transparency in the north-eastern states.

These curves are given here in the hope that others might be encouraged to undertake similar observations next summer and fall. This star is so bright that it can be conveniently observed even with a 6-inch reflector, if well mounted and provided with clock drive and slow motions. The simple Baum amplifier already mentioned would be adequate.

REFERENCES

1. *Electronics*, p. 98, 1948.
2. *The Griffith Observer*, p. 128, 1950.
3. *Pub. Goodsell Obs.*, no. 12, 1947.

Observations received during June and July, 1952: In June, 4,788 observations were contributed, and in July 5,604, making a good total of 10,392 received from the following 74 observers:

	June		July			June		July	
Observer	*No. Var.*	*No. Ests.*	*No. Var.*	*No. Ests.*	*Observer*	*No. Var.*	*No. Ests.*	*No. Var.*	*No. Ests.*
Adams, R. M.	43	140	53	177	Jerabek, H. S.	...	...	5	13
Ahnert, Paul	32	85	35	162	Johnsson, R. G.	15	19	16	22
Ancarani, Mario	31	57	29	53	Kelley, L. A.	19	34	20	28
Anderson, C. E.	89	136	111	151	Kelly, F. J.	13	13	11	20
Archer, S.	...	...	1	71	Kirchhoff, Peter	24	56	31	51
Beidler, H. B.	...	...	2	5	Knowles, J. H.	2	2	...	...
Bicknell, R. H.	26	364	23	294	de Kock, R. P.	124	541	145	653
Blunck, V. H.	3	5	6	14	Lacchini, G. B.	105	150	101	112
Boone, A. R.	...	...	8	8	Leutenegger, E.	...	...	18	19
Boutell, H. G.	6	26	5	17	LeVaux, H. A.	...	...	153	160
Buckstaff, R. N.	...	...	7	14	Mebius, W. G.	9	12	4	4
Chandra, R. G.	37	48	...	...	Melville, E. C.	15	31	12	33
Charles, D. F.	20	31	19	28	Miller, W. A.	40	41	39	53
Chassapis, C.	79	193	68	193	Milone, L. A.	28	44	33	73
Cragg, T. A.	44	45	179	179	Montague, A. C.	27	52	43	82
Dafter, Rosina	7	38	...	...	O'Byrne, S. L.	21	31	6	11
Darling, Birt	...	...	10	10	Oravec, E. G.	66	165	64	204
Darnell, P. B.	1	4	...	...	O'Sullivan, W. H.	14	27	10	22
Darsenius, G. B.	62	135	4	6	Overbeek, M. D.	40	119	48	196
Diedrich, George	1	1	3	10	Parker, P. O.	17	17	39	39
Domke, Klaus	...	...	22	160	Pearcy, R. E.	29	29	23	23
Elias, D. P.	72	272	...	...	Peltier, L. C.	49	134	50	194
Estremadoyro, G. A.	...	...	5	5	Peter, Hermann	45	649	44	514
Estremadoyro, V. A.	6	7	...	...	Pohl, Eckhard	...	...	23	112
Fernald, C. F.	77	103	137	221	Renner, C. J.	165	165	233	262
Ficonetti, Rene	...	...	36	59	Reynolds, F. H.	...	...	4	10
Fisher, Y. W.	7	26	6	37	Rick, Louis	1	1	1	2
Ford, C. B.	111	117	123	133	Rosebrugh, D. W.	17	87	19	109
Galbraith, W. H.	32	40	45	150	Segers, C. L.	10	11	...	...
Georgoolis, Stam	11	11	11	39	Taboada, Domingo	26	26	7	7
Goodsell, J. G.	...	...	2	2	Tarbell, E. D.	...	...	12	17
Greenley, R. M.	37	50	48	57	Upjohn, L. N.	...	...	30	30
Hales, LaVaughn	...	...	2	4	Venter, S. C.	59	99	59	71
Hartmann, Ferdinand	126	133	114	122	Whitehill, S. L.	...	...	5	5
Holloway, J. L.	...	...	7	13	Wyckoff, Jerome	1	1	...	...
Howarth, Mark	19	19	...	...	Yamada, Tatsuo	26	70	24	41
Isaak, George	27	64	9	13	Zahner, D. D.	8	12	5	5

Nova Search. Nova search reports were received in November from 7 observers; December, 7; January, 12; February, 12; March, 12; April, 13; and in May from 15 observers. In the following table we list for each observer: month of observation; areas observed (in italics); number of nights region was checked; and the limiting magnitude.

Adams, R. M., Nov.—*16, 17:* 2, 8; *39, 40, 86, 87:* 3, 8; Dec.—*16, 17, 31, 32, 33, 34, 39, 40:* 7, 8; Jan.—*16, 17, 31, 32, 33, 34, 53, 54, 65, 66:* 5, 8; Feb.—*16, 17, 31, 32, 33, 34, 53, 54, 65, 66:* 4, 8; Apr.—*53, 54, 65, 66, 71, 72:* 4, 8; May—*53, 54, 71, 72:* 4, 8.

Blunck, V. H., Nov.—*8, 9, 10:* 2, 6; May—*8, 9, 10:* 6, 6.

Darsenius, G., Nov.—*Dome:* 5, 2; *Dome:* 5, 1; *16:* 8, 6; *16:* 2, 5; *17:* 7, 6; *17:* 3, 5; Dec.—*Dome:* 3, 2; *Dome:* 1, 1; *16, 17:* 5, 6; *16, 17:* 1, 5; Jan.—*Dome:* 9, 2; *16, 17:* 10, 6; Feb.—*Dome:* 4, 2; *16, 17:* 7, 6; *16, 17:* 3, 5; Mar.—*Dome:* 5, 2; *16, 17:* 7, 6; Apr.—*Dome:* 6, 2; *16, 17:* 8, 6; *16, 17:* 3, 5; May—*Dome:* 4, 2; *16, 17:* 6, 6; *16, 17:* 4, 5.

**DeKinder, F., Apr.—*36:* 6, 6; May—*37:* 13, 6

*Diedrich, G., Nov.—*78:* 1, 4; Dec.—*Dome:* 3, 2; *Dome:* 1, 1; *56:* 2, 6; *56:* 2, 4; *78:* 1, 4; Jan.—*Dome:* 1, 2; *Dome:* 1, 1; *56:* 2, 6; Feb.—*Dome:* 3, 2; *56:* 3, 6; Mar.—*Dome:* 2, 2; *56:* 2, 6; *56:* 1, 4; Apr.—*Dome:* 4, 2; *56:* 5, 6; May—*Dome:* 7, 2; *Dome:* 1, 1; *56:* 7, 6; *78:* 1, 4.

*Diedrich, Del., Dec.—*Dome:* 1, 2; *94:* 1, 5; *94:* 1, 4; Jan.—*Dome:* 2, 1; *94:* 1, 4; *94:* 1, 3 Feb.—*94:* 1, 6; Mar.—*Dome:* 1, 2; *94:* 2, 4; Apr.—*Dome:* 1, 2; *94:* 2, 6; *94:* 1, 5; May—*Dome:* 2, 2; *94:* 3, 6

**Dufresne, R., Jan.—*28:* 7, 6; Feb.—*82:* 7, 6.

**Milton, E., Jan.—*10, 46:* 9, 6; Mar.—*10, 46:* 7, 6; Apr.—*10, 46:* 6, 6; May—*10:* 10, 6; *46:* 2, 6.

**Noseworthy, T., Jan.—*26:* 7, 6; Feb.—*81:* 7, 6; Mar.—*82:* 8, 6; Apr.—*Half Dome* (*N*): 7, 6; *82:* 7, 6; May—*82:* 13, 6

*Rick, J. J., May—*Dome:* 1, 1; *79:* 1, 4.

*Rick, L., Nov.—*Dome:* 4, 2; *18, 63:* 2, 5; *18, 63, 65:* 2, 4; Dec.—*Dome:* 2, 2; *Dome:* 3, 1; *18:* 4, 5; *18:* 1, 4; *63:* 1, 5; *63:* 4, 4; *65:* 3, 5; Jan.—*Dome:* 3, 1; *18:* 3, 4; *65:* 3, 4; Feb.—*Dome:* 1, 2; *Dome:* 3, 1; *18, 65:* 1, 5; *18, 65:* 2, 4; Mar.—*Dome:* 1, 2; *Dome:* 1, 1; *18, 65:* 1, 5; *18, 65:* 1, 4; May—*Dome:* 2, 2; *Dome:* 4, 1; *18:* 3, 4; *63:* 2, 4; *65:* 1, 4.

Rosebrugh, D. W., Nov.—*Dome:* 3, 3; *1, 34:* 3, 4; Dec.—*Dome:* 6, 3; *Dome:* 1, 2; *1, 34:* 5, 4; Jan.—*Dome:* 2, 3; *1, 34:* 1, 4; Feb.—*Dome:* 2, 4; *Dome:* 4, 3; *1, 34:* 3, 4; Mar.—*Dome:* 3, 3; *Dome:*1, 2; *1:* 1, 4; *34:* 3, 4; *34:* 1, 3; Apr.—*Dome:* 5, 3; *1:* 2, 4; *34:* 4, 4; May—*Dome:* 5, 3; *1, 34:* 2, 4.

Smith, F. W., Nov.—*3, 4:* 6, 6; Dec.—*3, 4:* 10, 6; Jan.—*3, 4:* 10, 6; Feb.—*3, 4:* 6, 6; Mar.—*3, 4:* 5, 6; Apr.—*3, 4:* 4, 6; May—*3, 4:* 5, 6.

**Steeves, M., Feb.—*36:* 6, 6; Mar.—*36:* 11, 4½; Apr.—*37:* 9, 6; May—*36:* 11, 6

**Williamson, I., Apr.—*38:* 10, 6; May—*38:* 11, 6.

**Wright, Mrs. S., Jan.—*80:* 7, 6; Feb.—*80:* 5, 6; Mar.—*80:* 5, 4½; Apr.—*Half Dome* (*S*): 6, 6; *80:* 6, 6; May—*80:* 5, 1.

**Zackon, D., Mar.—*102:* 6, 6.

**Zorgo, Mrs. K., Jan.—*51:* 8, 6; Feb.—*101:* 5, 6; Mar.—*101:* 7, 4; Apr.—*101:* 12, 6.

*Black River Astronomical Society
**Montreal Centre of R.A.S.C.

Harvard College Observatory
Cambridge 38, Massachusetts
August 15, 1952.

NOTES FROM OBSERVATORIES

David Dunlap Observatory

President Sidney Smith of the University of Toronto has announced that Dr. John F. Heard has been appointed Director of the David Dunlap Observatory and Head of the Department of Astronomy at the University, and also has been promoted to the rank of Professor of Astronomy. He succeeds Dr. Frank S. Hogg, who died on Jan. 1, 1951. Dr. Heard was born in St. Thomas, Ontario, and received his early schooling there. He was awarded a B.A. from the University of Western Ontario, and an M.A. and Ph.D. in physics from McGill. After studying as an 1851 Exhibition Scholar at the University of London, he received a Ph.D. there in 1934. The following year he came to the University of Toronto as instructor. As Associate Professor, he has been Acting Head of the department since early in 1951. From 1940 to 1945 Dr. Heard was with the R.C.A.F., rising from Flying Officer to Squadron Leader. His interest in navigation continues for he is a Special Lecturer each year at the Air Navigation School at Summerside, P.E.I., and is on the Advisory Council for Air Navigation of the National Research Council of Canada. Readers of this Journal are well acquainted with Dr. Heard, and his interest in stellar spectra. He was President of the Toronto Centre of the Society from 1947 to 1949, and is now National Vice-President. His many friends in The Royal Astronomical Society of Canada join with the staff of the Observatory in expressing their pleasure at his new appointment.

Mr. Edwin B. Weston, M.A., who until recently has been a graduate student and research assistant in astronomy at the University of Michigan, in July joined the staff of the David Dunlap Observatory of the University of Toronto with the title of Lecturer. He has specialized in nebular photometry and stellar spectroscopy and, in addition to his work on current Observatory programmes and teaching duties, will continue his studies of reflection nebulae and peculiar stellar spectra.

Mr. R. L. Baglow, who has been a lecturer on the staff since 1948, left at the end of June to take a post with the Operational Research Group, Ottawa. Mr. Ian Halliday, who has been assisting in the department and studying spectral classification and luminosity effects towards the Ph.D. degree, is leaving at the end of September to fill a position at the Dominion Observatory, Ottawa.

Assistants on the staff during the summer were G. A. Bakos, Olga Boshko, Barry Gunn, Sally Hogg, Donald Morton and Peter Saxton. These assistants helped to carry on the work of the observatory while some of the senior members were engaging in astronomical pursuits elsewhere: Dr. and Mrs. J. F. Heard at meetings of the International Astronomical Union at Rome, Dr. and Mrs. R. E. Williamson and Miss R. J. Northcott at the American Astronomical Society in Victoria and Dr. Helen S. Hogg as visiting professor at Harvard University.

Some changes in the equipment at the David Dunlap Observatory have been made recently. The aluminizing chamber for the 74-inch mirror was improved by replacing the two four-inch diffusion pumps with one ten-inch pump. The new pump has a speed roughly four times that of the original pair of pumps, resulting in a better vacuum and therefore a better coating of aluminum on the mirror.

A six-inch Cooke refractor is being erected in the previously unused north dome of the Administration Building. This instrument, formerly on the university campus, is to be used as a guiding telescope for various cameras that will be fastened to the telescope, making a small battery of astrographs.

The 19-inch reflector, successfully used in the past for the direct photography of globular clusters, was relieved of the somewhat unreliable Gerrish drive in favour of a more positive synchronous motor. Improved guiding was reported by the observers with this instrument. The 19-inch telescope has been used for several years with a photoelectric photometer at the Cassegrain focus. In order to provide space for an eyepiece or the photometer at this focus, alterations were made on the weights below the primary mirror.

The oscilloscopic microphotometer has been designed and built to study stellar spectrograms. This instrument has been described in the *Astronomical Journal*, vol. 57, p. 15, 1952. The stellar and comparison spectra are scanned for density, and traces are obtained upon an oscilloscope screen with wave-length as the horizontal co-ordinate and density (and therefore a measure of intensity) as the vertical one. There are four traces in all, one corresponding to each of the two stellar and two comparison spectra. Spectral classification measurements have been made, using the Morgan system as a basis. Radial-velocity measures are presently being tested, using the fairly objective method of lining up the traces on the screen. Different plates on the same star can be conveniently compared on the screen. This is particularly useful in the cases of spectrum variables and spectroscopic binaries.

NOTES AND QUERIES

The Sun and Laboratory Flame Temperatures

The determination of the temperature of low-pressure gases, such as flames, is not a simple procedure, but one requiring ingenuity. Nearly a century ago Kirchhoff found that the spectrum of a gas placed in front of a hotter source of continuous radiation consists of dark absorption lines at just those wave-lengths that it regularly emits. This principle has been used in a standard laboratory apparatus for determining flame temperatures. The apparatus consists essentially of a source of continuous radiation, an adjustable absorbing medium and the flame whose temperature is to be determined. The light from the source, passing through the absorbing medium and the flame, is examined with a spectroscope. The absorbing medium is adjusted until the spectrum of the flame is *just reversed*. Then the temperature of the flame is exactly equal to the brightness temperature of the background source; this can be measured with an optical pyrometer. It is thus necessary to have a source of continuous radiation which is hotter than the flame to be examined. Carbon is the hottest terrestrial source, at a temperature of 6400°F.

In attempting to get the temperature of a hydrogen-fluorine flame, Raymond H. Wilson, Jr., (*P.A.S.P.*, vol. 64, p. 105, 1952) found that the flame was hotter than the carbon source and no reversal of the spectrum lines could be seen. A still hotter source was required. Since none could be found on earth, Wilson turned to an astronomical source, the sun. In an ingenious way sunlight was fed through the apparatus, and the intensity cut down by an absorbing medium until the spectral lines were just reversed. The temperature was determined to be 7200°F. The fact that the temperature of the sun, 93 million miles away, is more easily determined than that of a flame in the physical laboratory is indeed interesting.

R.J.N.

Water on Mars

In the *Astronomical Journal of U.S.S.R.*, vol. 26, no. 5, 1949, V. G. Fesenkoff theoretically discusses the existence of a free water surface on Mars. He assumes the polar caps to be of ice, which melts quickly during the warm season. The fact that the presence of water vapour has not been

detected spectroscopically, would make it reasonable to think that the dimensions of the free water surface will be small. However, it should be possible to detect it as a more or less bright point of the reflected sun's image.

The result of Fesenkoff's consideration is that the surface, which would reflect the whole image of the sun to the earth would be 7.4 km. in diameter and its brightness would be 1.5 mag. Such a point should be visible even in a small telescope and it should increase the brightness of the planet considerably.

On the other hand the large telescopes could show the reflection of a point 2500 times weaker than that originally calculated. This would make the lower limit for the supposed water surface 300 metres in diameter. As one has never observed the reflection of the sun on Mars, Fesenkoff concludes that the melting of ice makes pools of water of about 10 to 100 metres in diameter. The water is probably very scarce on Mars.

In connection with this problem it would be interesting to mention the presence of clouds on Mars, seen by many observers. (*Mitteilungen für Planetenbeobachter*, vol. 5, no. 5, 1952). In the days before opposition this year, the disk of the planet appeared veiled with faint clouds. Dr. Sandner in Berlin observed a slow-moving cloud for 42 days while he and M. R. Baum observed another phenomenon, which they call a snow-storm. A bright spot near the south pole cut off considerably the visibility of that region for about two weeks.

G. A. Bakos

Volcanoes and World Weather

Mr. Andrew Thomson, Controller of the Meteorological Service of Canada, in his presidential address at the At-Home of the R.A.S.C. in 1951, showed that the winter temperatures in Canada have gone up about five degrees during the last hundred years. The evidence comes from records of the ornithologists as well as of the meteorologists, since birds formerly limited to the latitude of Connecticut are now in southern Canada.

The effect of warmer winters is prevalent over most of the northern hemisphere. The earth has been going through long-term fluctuations in climate for longer than historic time, as shown by the geological records of the ice ages.

Theories to account for these changes are numerous. Harry Wexler, Chief of the Science Services Division in the U.S. Weather Bureau, discusses this problem in the April 1952 issue of *Scientific American*. One theory is that major climatic changes have resulted from geological

changes in the earth itself. However, large changes in weather have occurred in regions of the earth where no topographical changes have occurred. Another suggestion is that the climatic changes are due to fluctuations in the amount of radiation received from the sun; however, no such changes are observed at the high altitude solar stations. The theory that the output of ultra-violet light from the sun is correlated with the sun-spot cycle and with weather has not been satisfactorily established.

The theory which Mr. Wexler discusses in detail is that volcanic explosions may be important in long-term weather changes. This hypothesis was developed from observations made of the solar radiation received at the Montpellier Observatory in Southern France during the years following the great volcanic explosion which occurred on August 27, 1883 on the island of Krakatoa in the Dutch East Indies (See this JOURNAL, vol. 40, p. 161, 1946). This volcano blew up some 13 cubic miles of rock, dust and ash; the fine ash rose fully 20 miles into the atmosphere. The dust drifted across the ocean and three months later was over Europe. At Montpellier the radiation from the sun was suddenly reduced from 30 per cent. above normal to 20 per cent. below normal. For three years the observed solar energy there remained 10 per cent. below normal. In the next three decades there were several other major volcanic explosions, each throwing ash into the atmosphere, which in turn reduced the solar energy on the earth's surface.

The observations at Montpellier led W. J. Humphreys, among others, to investigate the effect of the dust blanket on weather. It was found that although a dust blanket cuts out some of the solar radiation, it does not stop the longer heat waves from being radiated back from the ground, so that the result might be a lowering of the ground-level temperature by several degrees. Since it is unlikely that such a dust blanket would be uniform, the effect would be different in different regions. These temperature changes would make corresponding changes in the air currents, and thus would make changes in the weather. It would take an amazingly long time for the dust particles to settle out of the atmosphere, so it is conceivable that an ice age would be brought on, if the dust pall were nourished by a series of large volcanic explosions.

This theory, as developed by Humphreys, could not be corroborated from observation. However, it has been revived by the discovery that dust particles can act as nuclei to form ice crystals; the dust pall could further reduce surface temperatures by increasing cloudiness. Also, since 1912 there have been no major volcanic eruptions and during this time the

winters have been growing steadily warmer in the northern hemisphere. Other theories cannot explain this warming up.

R.J.N.

The Lick 120-inch Reflector

The dome for the 120-inch reflector of the Lick Observatory was completed last March, according to W. W. Baustain in the June issue of the *Publications of the Astronomical Society of the Pacific*. The dome contains offices, air-conditioned bedrooms, library-lounge and kitchenette as well as space for a laboratory, deep-freeze refrigerator for plate storage, dark rooms, storeroom and optical shop. The 120-inch blank and grinding equipment were moved to the optical shop towards the end of last year. The work on the mirror is expected to require from one and a half to three years to complete.

C.A.C.

The Bicentennial of the Adoption of the Gregorian Calendar in England

The month of September this year marks the two hundredth anniversary of the adoption of the Gregorian calendar by England and the British Dominions. In order to visualize the confusion that this move made, just try to imagine how you would explain to an uneducated mob that eleven days were to be dropped from the calendar—that there would be nothing between September 2 and September 14, and that holy days like Christmas would be out of step with their previous celebrations!

The Gregorian calendar had been wisely introduced by Pope Gregory XIII in 1582, because the value assumed for the tropical year by the Julian calendar was adding three extra days every four hundred years. The Pope instituted a clever way of abolishing these by making century years leap years only when divisible by 400. There remained the problem of resetting the vernal equinox where it should be. To do this, it was necessary to drop ten days from the calendar. The Catholic countries accepted the change meekly, but the Protestant church and the Greek church rejected the Pope's authority and refused to make the change. The British Dominions held out for nearly two centuries. When the change was finally made there, it amounted to eleven days. Turkey was one of the last countries to adopt the Gregorian calendar, in 1927.

The change in England was made under great opposition. Mobs formed in the streets, shouting "Give us back our fortnight!", and there were violent riots, especially in Bristol where some people were killed. Although

the act of Parliament had been carefully framed to prevent injustices, such as landlords collecting rents for the missing days, it was not easy to explain to people that they were not being cheated out of eleven days of their life. Some people even thought they would die eleven days sooner!

The editors of *Sky and Telescope* have unearthed a copy of "The Daily Advertiser" for September 14, 1752. The front page carries an advertisement for an almanac giving both Julian and Gregorian calendars, and the following quaint rhyme:

> What a whimsical change will be wrought in our life,
> By this odd-fangled Leap-Frog of old and new Style;
> TIME hastens his Pace, in his boundless Career,
> To add to the Jokes of this marvellous Year;
> When from *Britons* eleven broad Days took their Flight,
> And, waking, all swore they had slept but one night.

H.S.H.

REVIEW OF PUBLICATIONS

Astronomischer Jahresbericht, vol. 49, published by the Astronomisches Rechen-Institut, Heidelberg, Augustinerstrasse 15, Seminarienhaus, 1952. Price, 56 marks.

This important German periodical of which the 49th volume, covering the astronomical literature for the year 1949, has just been received, is an invaluable reference work for astronomers. All the astronomical literature for the year is listed under fourteen main classifications with many sub-classifications, and all papers are briefly summarized in German. There are lists of astronomical periodicals and observatory publications and complete name and subject indexes.

J.F.H.

MEETINGS OF THE SOCIETY

AT TORONTO

April 8, 1952—The meeting was held in the McLennan Physics Laboratory with Mr. F. L. Troyer, President, in the chair.

The following nominee was elected to membership in the Society: Mr. Clifford C. Cook, 213 South Kingsway, Toronto 3.

The speaker of the evening, Dr. W. W. Morgan, Professor of Astrophysics at the University of Chicago, was introduced by Dr. R. E. Williamson. The subject of his lecture was "The Structure of our Galaxy."

The most numerous stars are the red dwarfs, not the naked eye stars. The next most frequent are the orange dwarfs, then the solar dwarfs followed by the white dwarfs, all belonging to the least luminous class of stars. If a red filter is used the number of stars appears to decrease and many more hazy areas appear. Photographs of this nature show that we are looking at the galaxy edge-on. It is believed that we look much like M81. This is a typical spiral galaxy in which no bright stars appear in the nucleus, but all appear in the arms. Under the right photographic conditions the nucleus is small and almost starlike, and enlarged pictures show the absence of bright blue giants. It is interesting to note also how novae seem concentrated in the nucleus. This can be compared with the concentration of novae in our own galaxy, and it shows a parallel.

Another close spiral nebula that we can study in detail is the Andromeda nebula. The arms of this nebula also show the bright blue stars and dust clouds that characterize M81 and our own galaxy. When an H filter is used hydrogen spheres are found in these arms, associated with the blue giants, as had been predicted by theory, and they may be used to trace out the arms of a galaxy. These hydrogen emission regions are also present in our galaxy. Their distance can be found by determining the amount of interstellar absorption between them and the sun, or by determining the distances of the bright blue stars embedded in them by spectroscopic parallax. Four of these hydrogen emission regions are in the neighbourhood of Orion. A plot of these regions indicates that the spiral arms of our galaxy are trailing. A comparison of these regions in the Andromeda nebula with our own shows that they are of the same order of magnitude and frequency, and that the thickness of the arms is similar.

The North American nebula is another case where such a study can be made, and the results are in agreement with those made with the Andromeda nebula, M81, and our own galaxy.

Dr. Lloyd Morgan expressed the appreciation of the Toronto Centre for this interesting lecture and the meeting was adjourned.

BARBARA CREEPER, *Recorder.*

AT MONTREAL

October 25, 1951—The Annual Meeting was held at MacDonald Physics Building, McGill University, at 8.15 p.m. The President, Miss I. K. Williamson, was in the chair.

Mr. A. R. McLennan moved, Mr. T. Noseworthy seconded, that the following be admitted to membership: B. A. Norman, Miss E. Reid, Phillip Freygood, Michael Steeves, Thomas P. Walsh, Charles Fox, John D. Wilby, Reese W. Davis.

A number of gifts have been received by the Library, which were acknowledged by the President, with the thanks of the Centre.

Reports of the officers for the year 1950–51 were then received. In moving the adoption of the reports, Mr. W. H. Birtles complimented the officers on their presentations. Motion seconded by Mr. DeLisle Garneau, and carried.

The president then read an excerpt from the Massey report in which the activities of the R.A.S.C. were cited, with a particular mention of the Montreal Centre for its noteworthy achievement in carrying on without professional direction. Election of Officers and Council for year 1951–52 followed.

The President thanked the officers for their support and co-operation during the year, Dr. A. N. Shaw and McGill University for the facilities of the MacDonald Physics Building, and Mr. Reid, the Building Superintendent, for the services he has rendered in connection with the meetings. Acknowledgements were also made to the City of Westmount for assistance and co-operation in the Annual Star Night, and to the press for interest shown.

The President then introduced the speaker, Mr. T. Noseworthy, whose interest and activities since he became connected with the Centre, are so well known. Mr. Noseworthy, because of his notable interest, has spent two months at the David Dunlap Observatory, by invitation of the Observatory and his subject, "A Summer at the Dunlap," gave a description of the programme followed, and of the Observatory, illustrated by slides made from his own photographs. The work undertaken was to confirm Dr. Shapley's observations and study the periods of R V Tauri variables. Under the direction of Dr. Helen Hogg, he had photographed globular clusters with the 19-inch reflector, and exhibited slides made from photographs taken. He also showed slides of the 74-inch telescope, of which he gave a description. When photography was not possible, measurements and comparisons were made. The principal programme in which the David Dunlap Observatory has taken part has been the direct photographing of clusters, and the study of radial velocities.

The President thanked the speaker on behalf of the Centre, and followed by citing him as the first "graduate" of the Messier Club—the first member to identify and observe all the objects in Messier's Catalogue, and presented him with "Norton's Star Atlas" in recognition of his success.

In conclusion, the thanks of the Centre were expressed to the Refreshment Committee, and the meeting adjourned. Seventy-nine members and visitors were present.

November 8, 1951—The meeting was held at MacDonald Physics Building, McGill University on Thursday, at 8.15 p.m. The President, Miss I. K. Williamson, was in the chair. The speaker of the evening, Mr. J. W. Duffie, was then introduced, his subject being "Those Puzzling Fundamentals." Commencing with a flask containing coloured water, Mr. Duffie likened the flask to the crystal sphere of the ancients, and then explained the apparent motions of the heavens, and the celestial co-ordinates. With the aid of models, circumpolar stars, celestial equator and ecliptic were defined, and the reason given for winter temperatures at the time of perihelion. Again using models, the methods used to indicate the position of a body in the heavens, altitude and azimuth, and right ascension and declination, were explained. Parallax, precession, aberration and the retrograde motion of the planets were made apparent. Next the phases of the moon, its revolution and rotation were shown, and how libration occurs,

by which more than one half of the moon's surface may be observed although the same side of the moon is always presented to the earth. With the armillary sphere the positions of the sun in summer and winter were shown, the position of the full moon in the seasons and the elongations of the inner planets demonstrated. The phenomena of eclipses were also very thoroughly explained, as well as eclipse limits and frequencies, and to show how any possible combination of eclipses could occur, a most interesting diagram of his own making, was exhibited by the speaker.

In thanking the speaker, the President made particular reference to the excellent effects obtained by Mr. Duffie in the use of his models, and the great clarity with which his subject had been presented. The meeting then adjourned, 58 members and visitors having been present.

November 22, 1951—The meeting was held at MacDonald Physics Building, McGill University on Thursday, at 8.15 p.m. The President, Miss I. K. Williamson, was in the chair. The following were admitted to membership of the Centre on motion of Mr. F. DeKinder, seconded by Mr. W. H. Birtles: Geo. S. Sanderson, J. Howard, J. Cohen. Mr. DeKinder gave a brief explanation of the solar and lunar halos division of the observation committee, which was recently established under the leadership of Mr. Garneau.

E. E. Bridgen, Recorder.

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